Basic principles of LEOS

Task

- Detection, localization of leaks and assessment of leak rate in pipelines, tanks and waste deposits

Physical basis

- Transportation of leaking material according to diffusion process

Measuring technique

- Permeable and pressure - tight sensor tube along the component to monitored
- Central measuring system including a pump and sniffering gas detectors

Evaluation parameters

- Measuring of the gas concentration collected in the sensor tube as a function of the pumping time

- **Leak detection:** crossing of gas concentration above a threshold (detection time)

- **Leak location:** detection time multiplied by the measured gas flow velocity

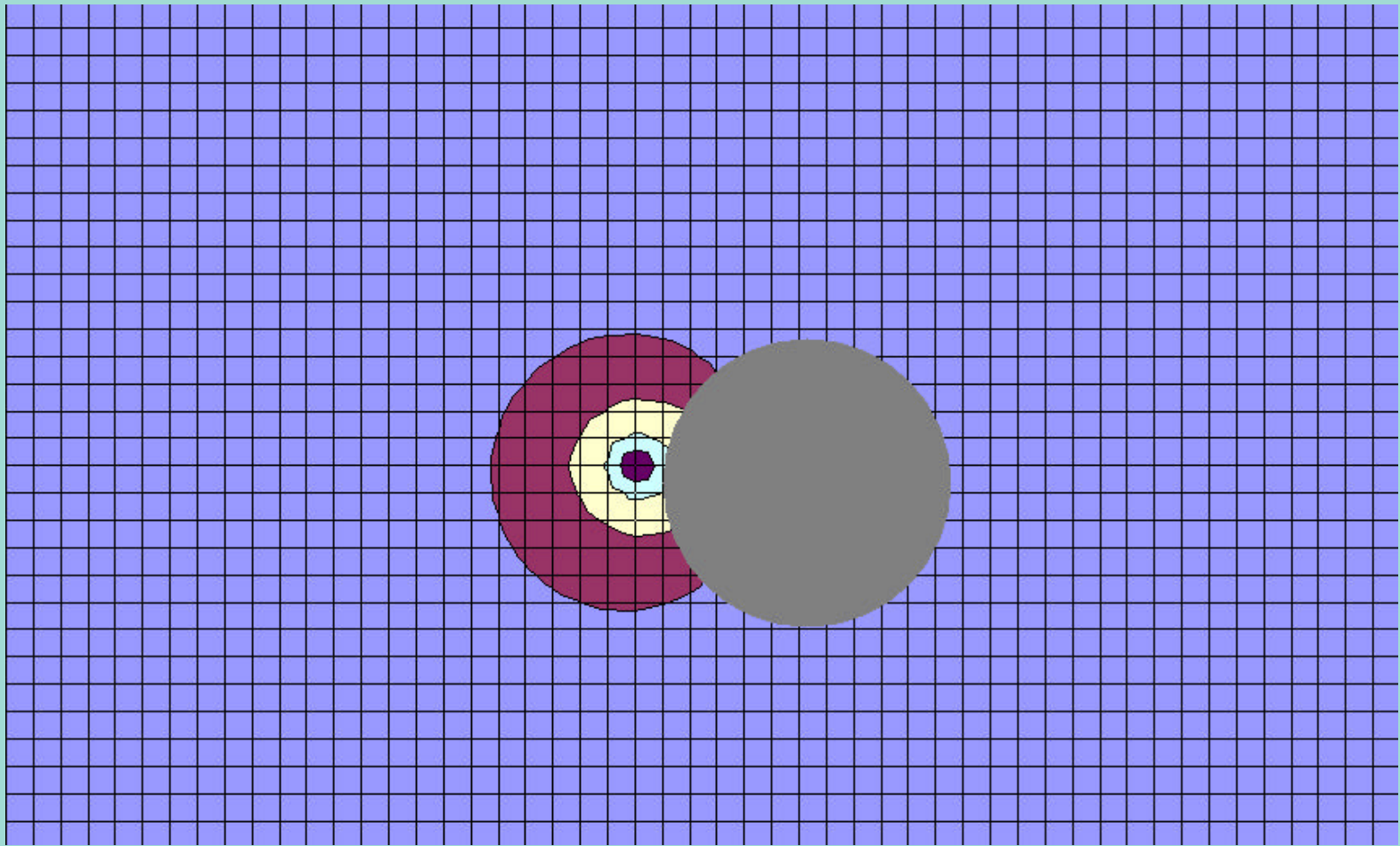- **Analysis:** gas probe analysis, pattern recognition methods by neural networks using up to 7 sensors
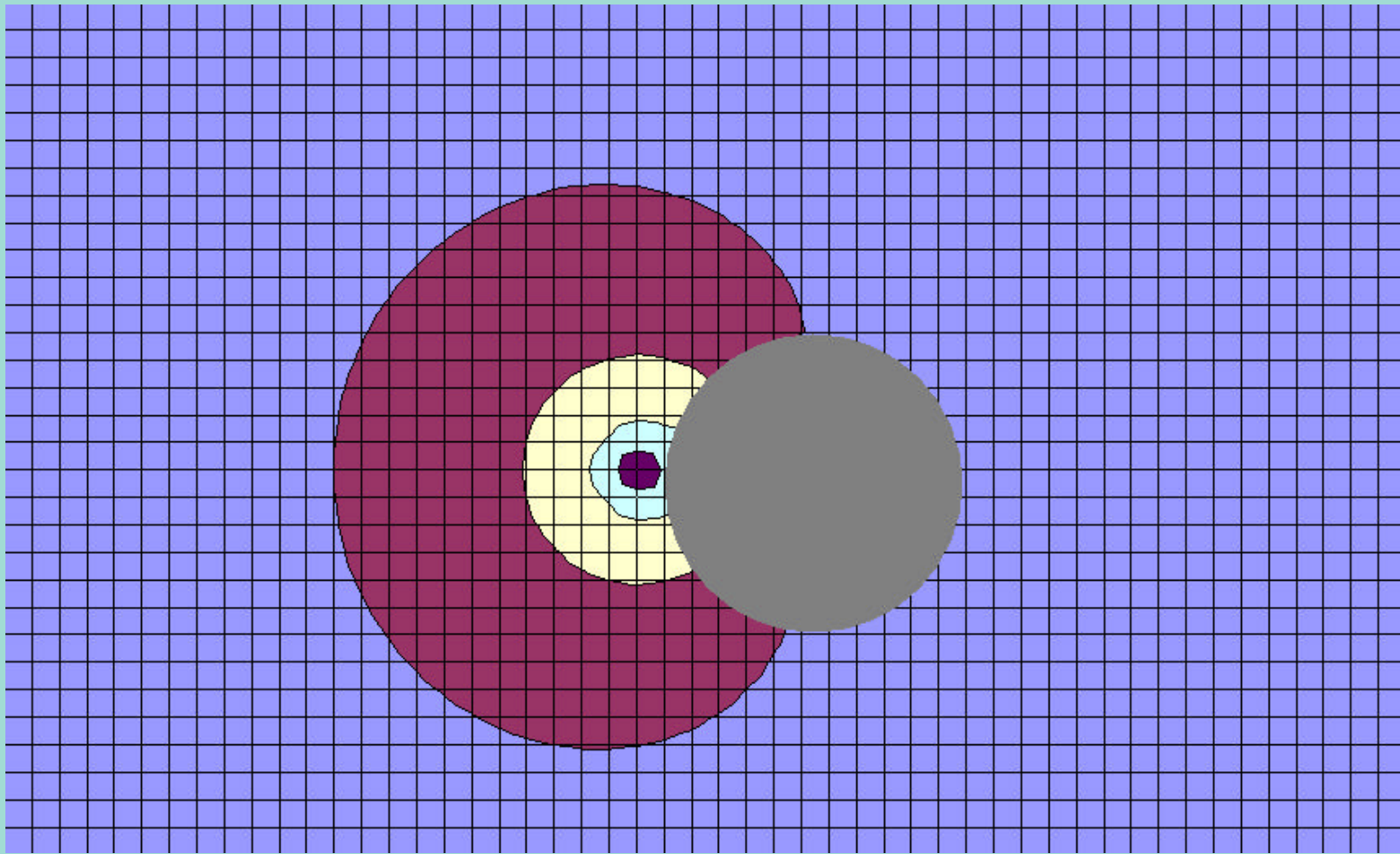
LEOS (Leak Detection and Location System)

SIEMENS

Diffusion around the Pipe - Phase 1
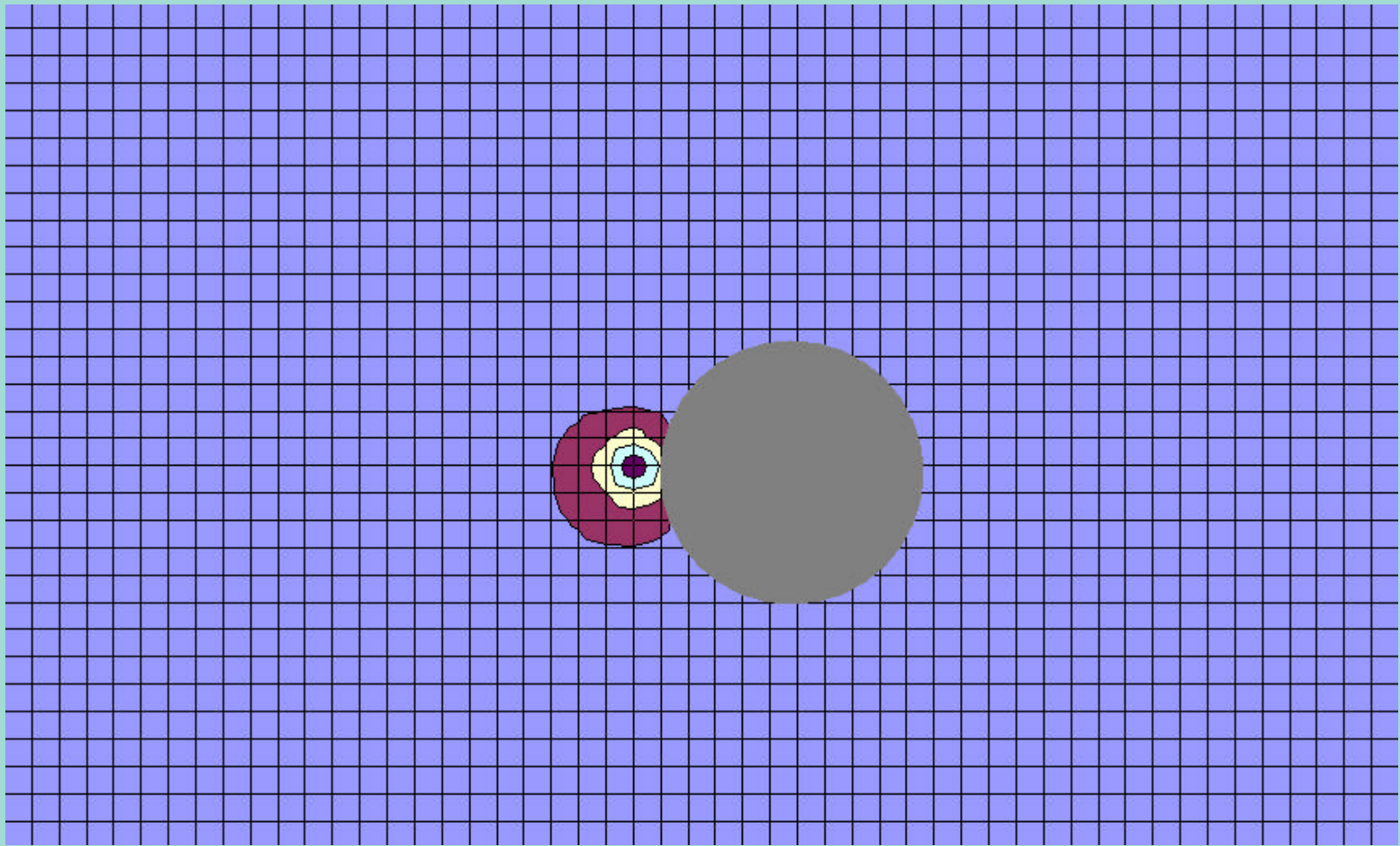
LEOS (Leak- and Location System)   **NW-D / 1999**

SIEMENS

Diffusion around the Pipe - Phase 2

LEOS (Leak- and Location System)   **NW-D / 1999**

Diffusion around the Pipe - Phase 3

LEOS (Leak- and Location System)   **NW-D / 1999**

SIEMENS

Diffusion around the Pipe - Phase 4

LEOS (Leak- and Location System)   **NW-D / 1999**

SIEMENS

Diffusion around the Pipe - Phase 5

Pipe shadow

Normal propagation

LEOS (Leak- and Location System)   NW-D / 1999

SIEMENS
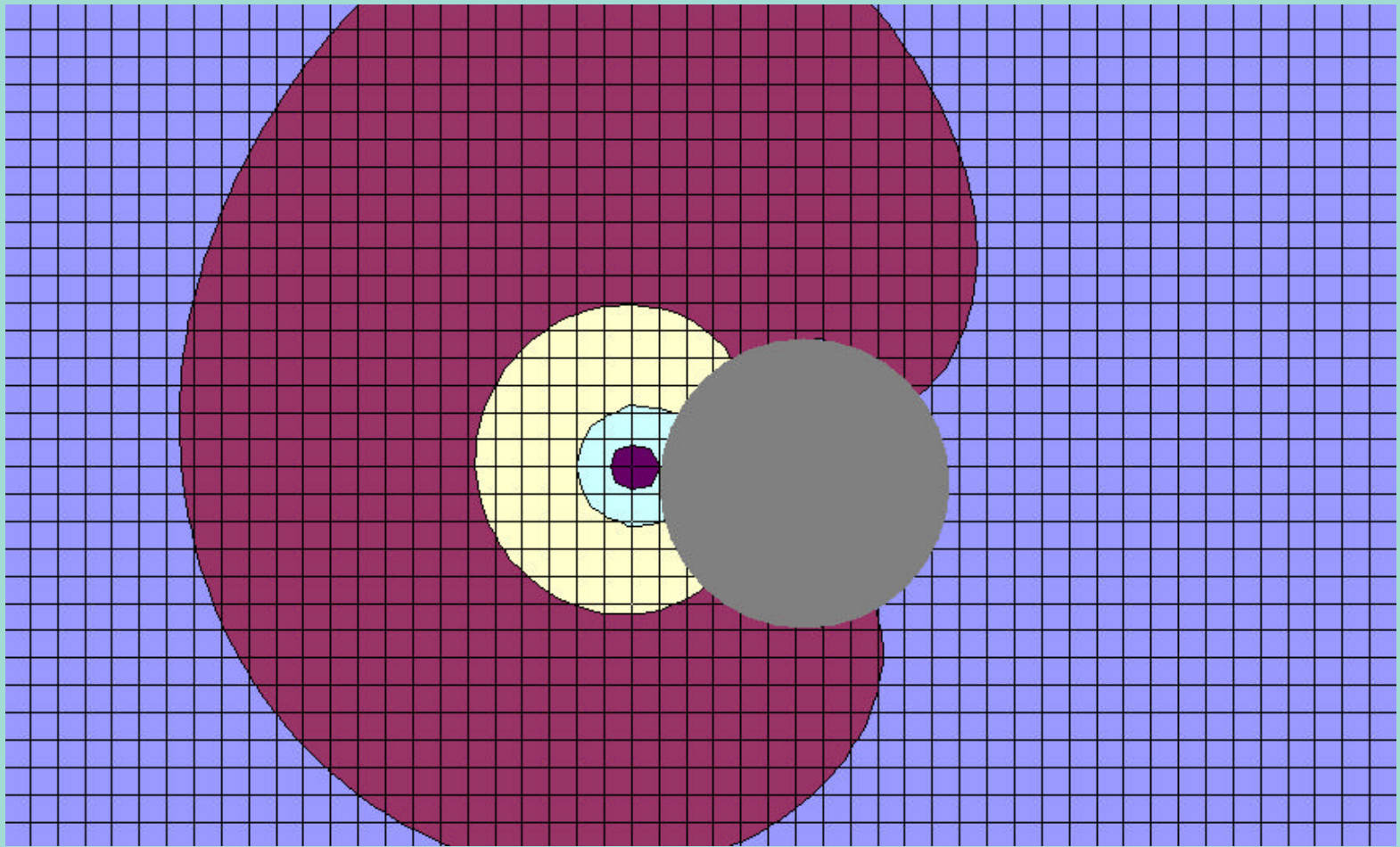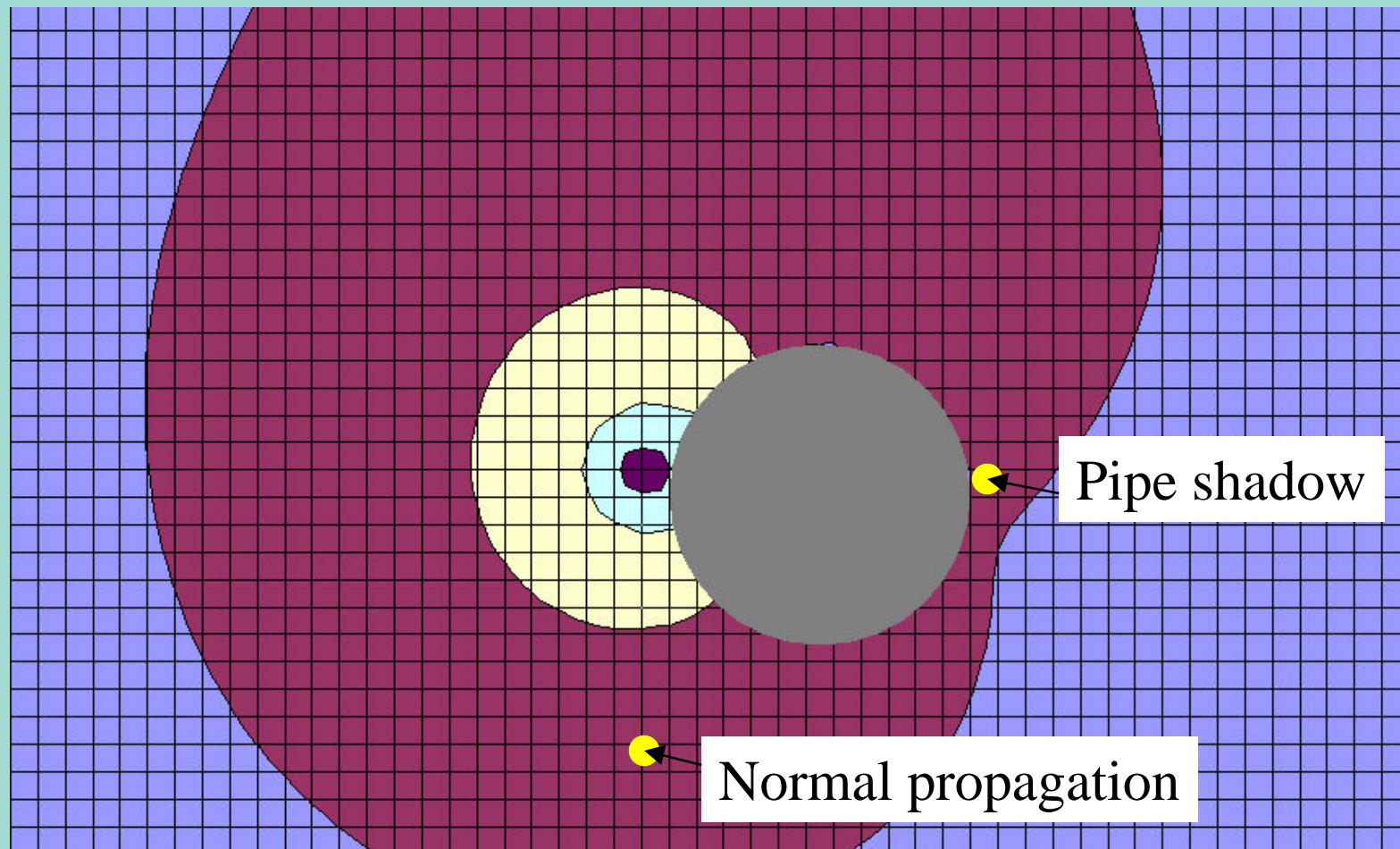
Diffusion around a pipe (2-dimensional Model)

LEOS (Leak- and Location System)   **NW-D / 1999**

SIEMENS
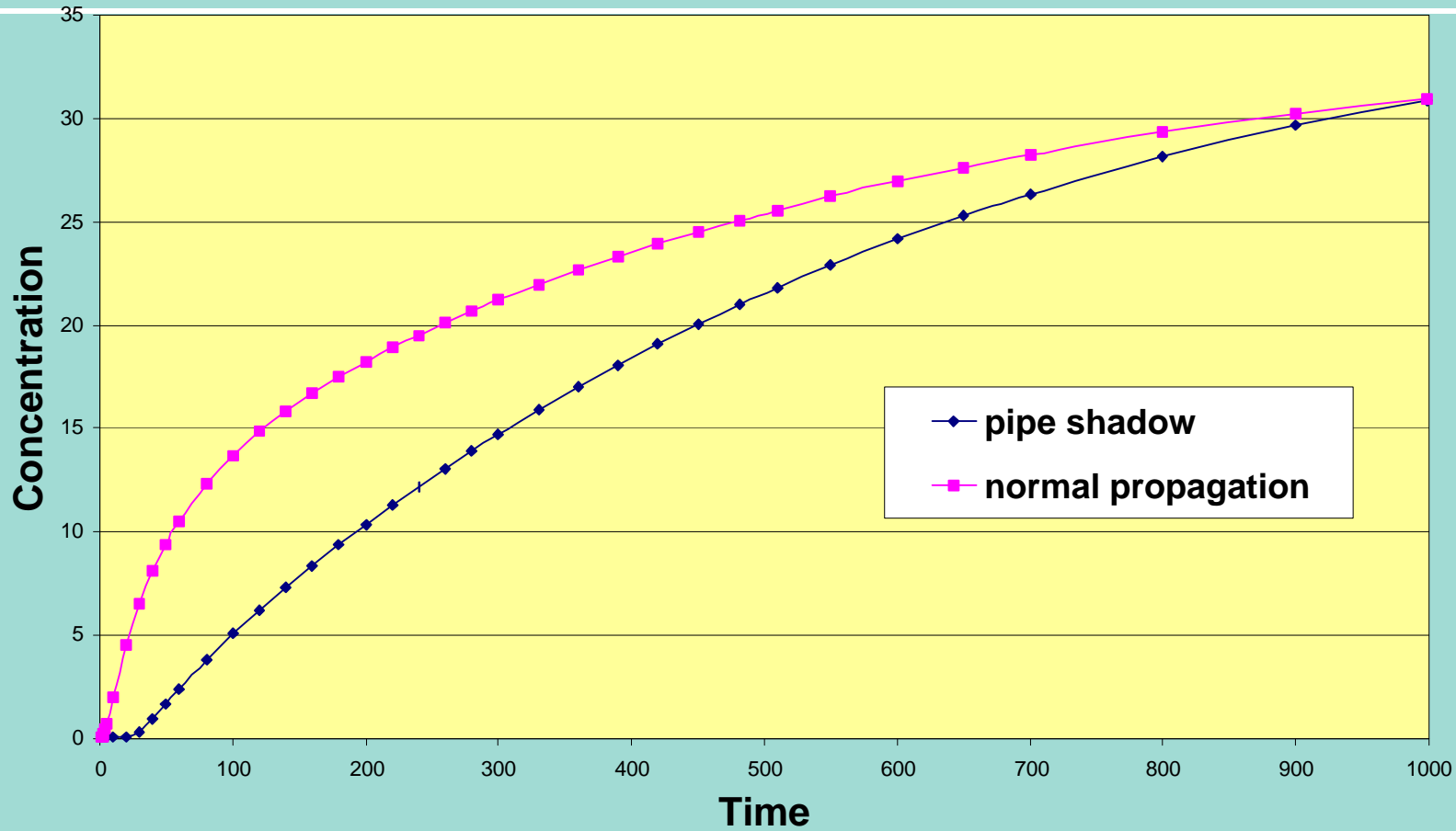
Structure of Sensor Tube

Diffusion Layer
of EVA

Protective braiding
of thin PE strips

Perforated gas
transport tube
of modified
hard PVC *)

*) alternative materials for special applications:

PP (polypropylen)
PVDF (polyvinylidenfluorid)

LEOS (Leak- and Location System)

NW-D / 1999

Mode of Operation

Small leak   Large leak

Diffusion through
the tube wall

Electrolysis cell

P — Pump
G — Gas sensor
E — Test gas

Low gas concentration   Dry and clean air   High gas concentration   LEOS sensor tube

Analysis

Gas concentration

Peak for large leak

Peak for large leak

Test peak

Transfer time 1 shows location 1

Transfer time 2 shows location 2

Total transfer time T corresponds to overall length of sensor tube

Pumping time (t)

LEOS (Leak Detection and Location System)

LEOS capabilities

➡️ **Detectable materials**

- ▫ All types of carbonats such as propan, crude oil, petrol, halogenized hydrocarbons, alcohols, ester, ether, ketones
- ▫ Anorganic gases (hydrogen, ammonia)

➡️ **Detection limits**

- ▫ Sensor tube: $\leq$ 10 µl / l for fluids
  $\leq$ 5 ml / l for gases
- ▫ Leaking material: $\leq$ 1 l / h for fluids
  < 0,1 m^3 / h for gases

➡️ **Monitoring length / - area**

- ▫ For each measuring system: pipeline: 15 km (up to 50 km for methan)
  waste deposits: < 100 ha ($\leq$ 35 km)

➡️ **Location accuracy:**

- ▫ better than ± 25 m for 5 km ($\hat{=}$ 0,5 %)

➡️ **Response time:**

- ▫ normal application: 24h
  special gas application: $\geq$ 0,5h (for short distances)
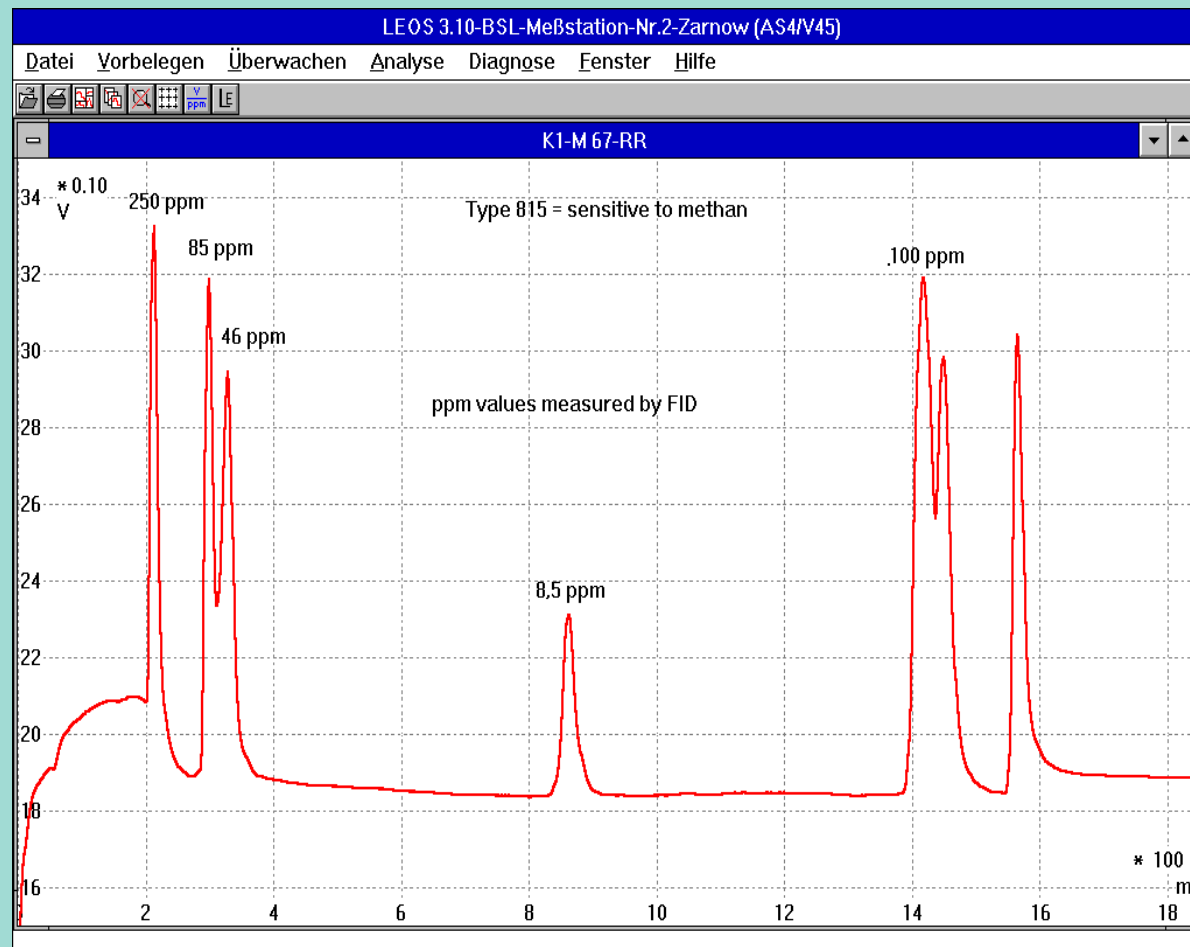
➡️ **Evaluation:**

- ▫ automatic leak alarm
- ▫ trending of leak indication
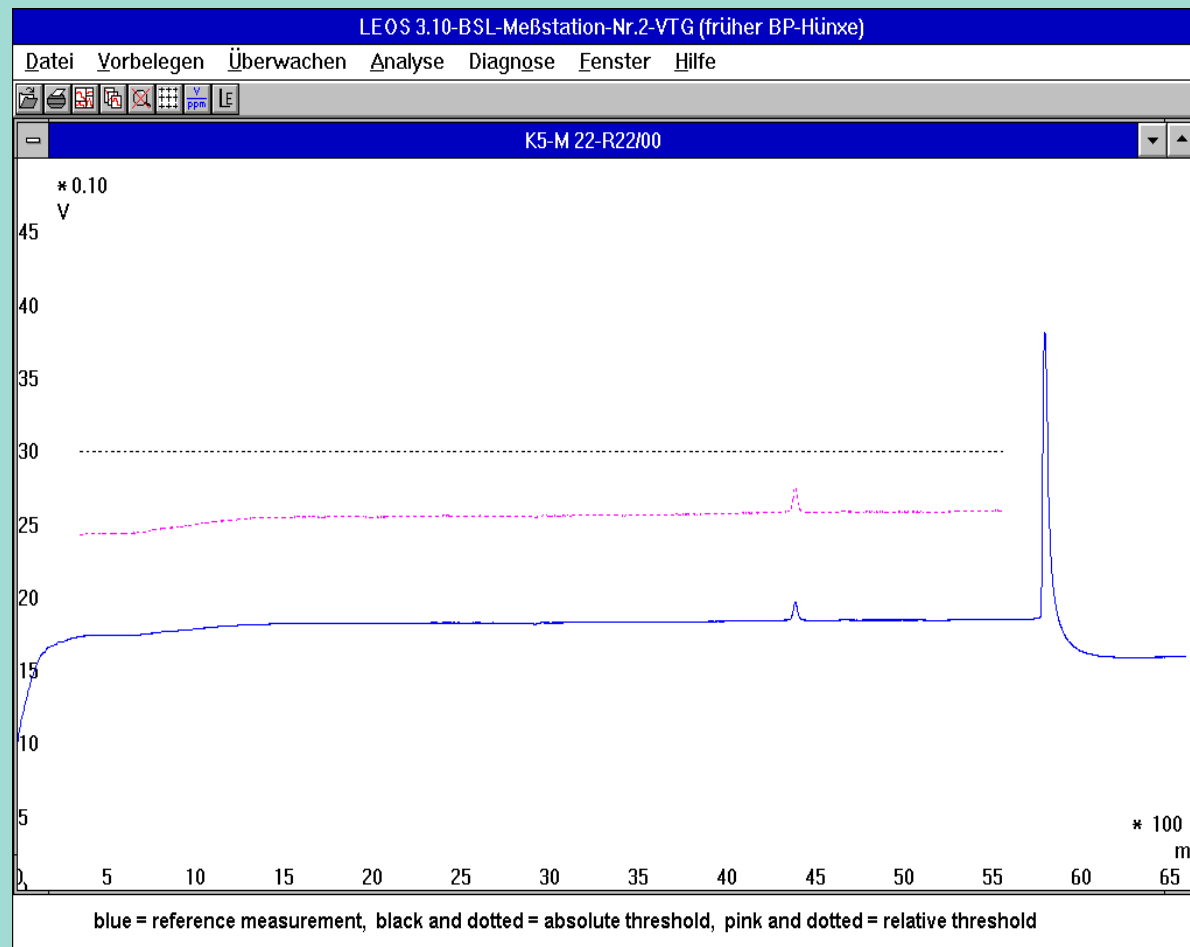- ▫ identification of leaking material

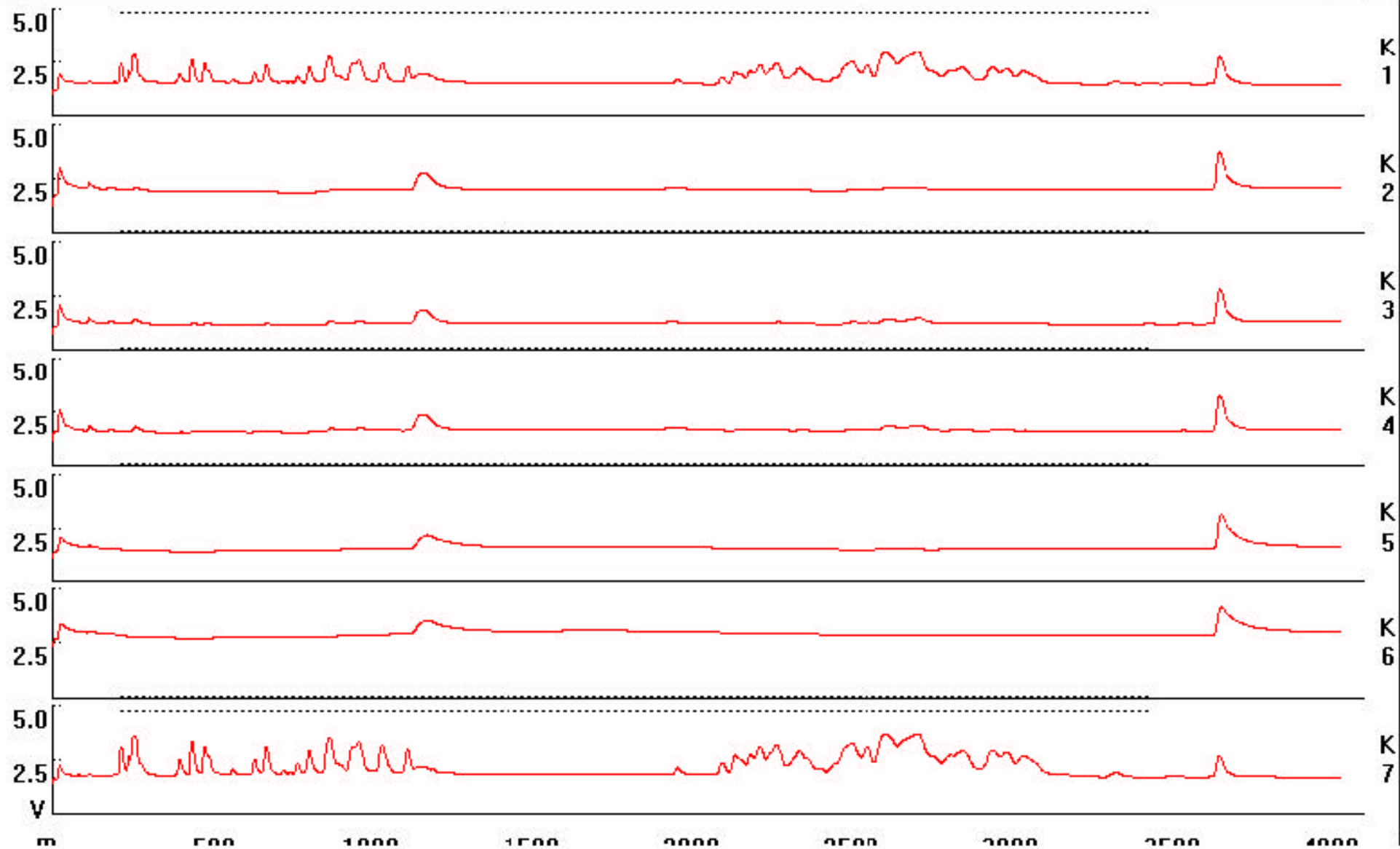LEOS (Leak Detection and Location System)

SIEMENS

LEOS Reference Location Plot
High Background of Methane at Selected Positions

SIEMENS

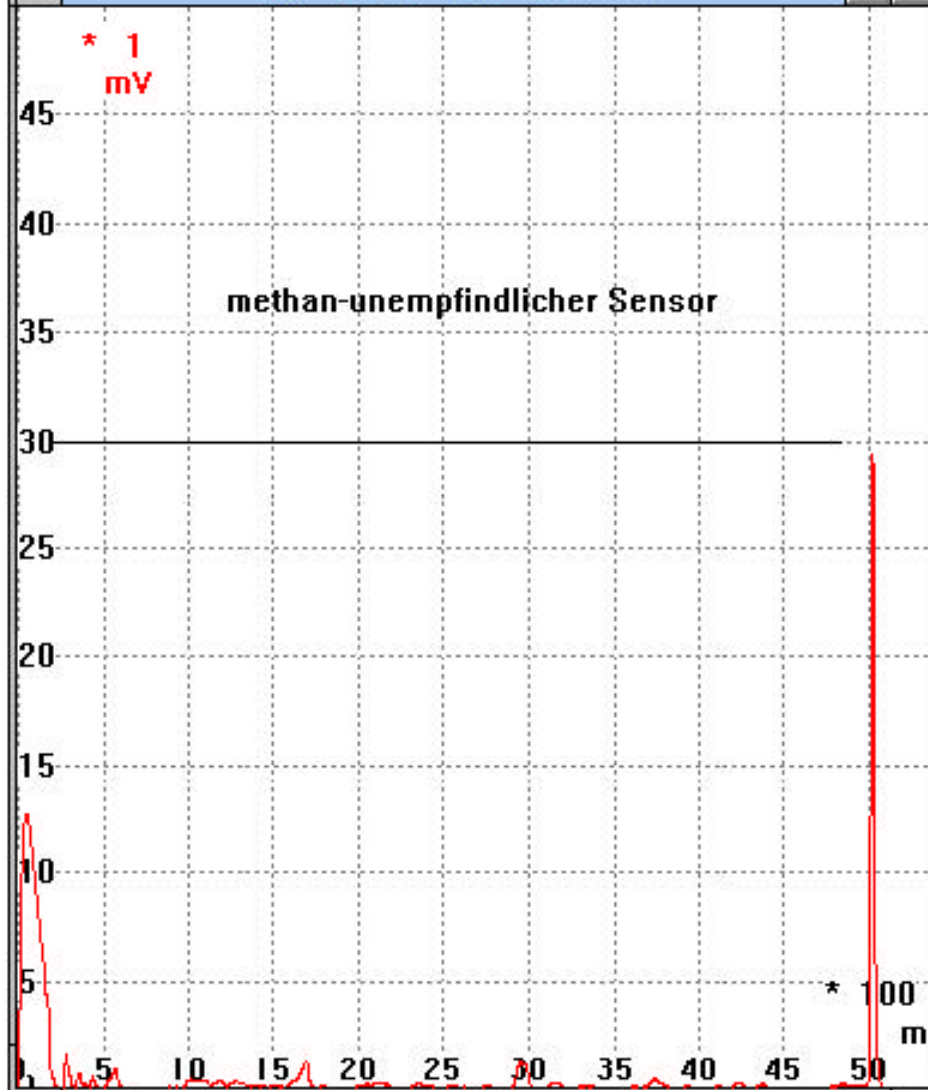## LEOS Reference Measurement
Low Background at VTG (BP) Pipeline Bundle

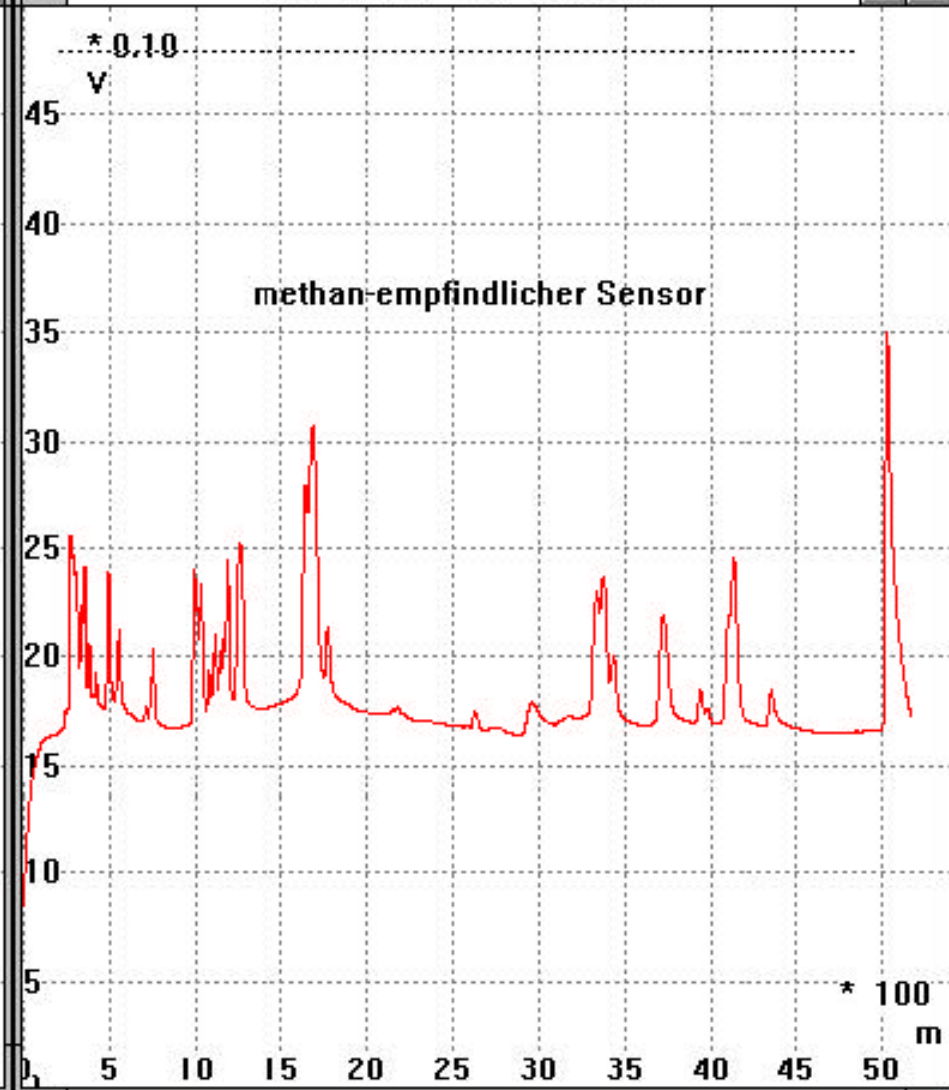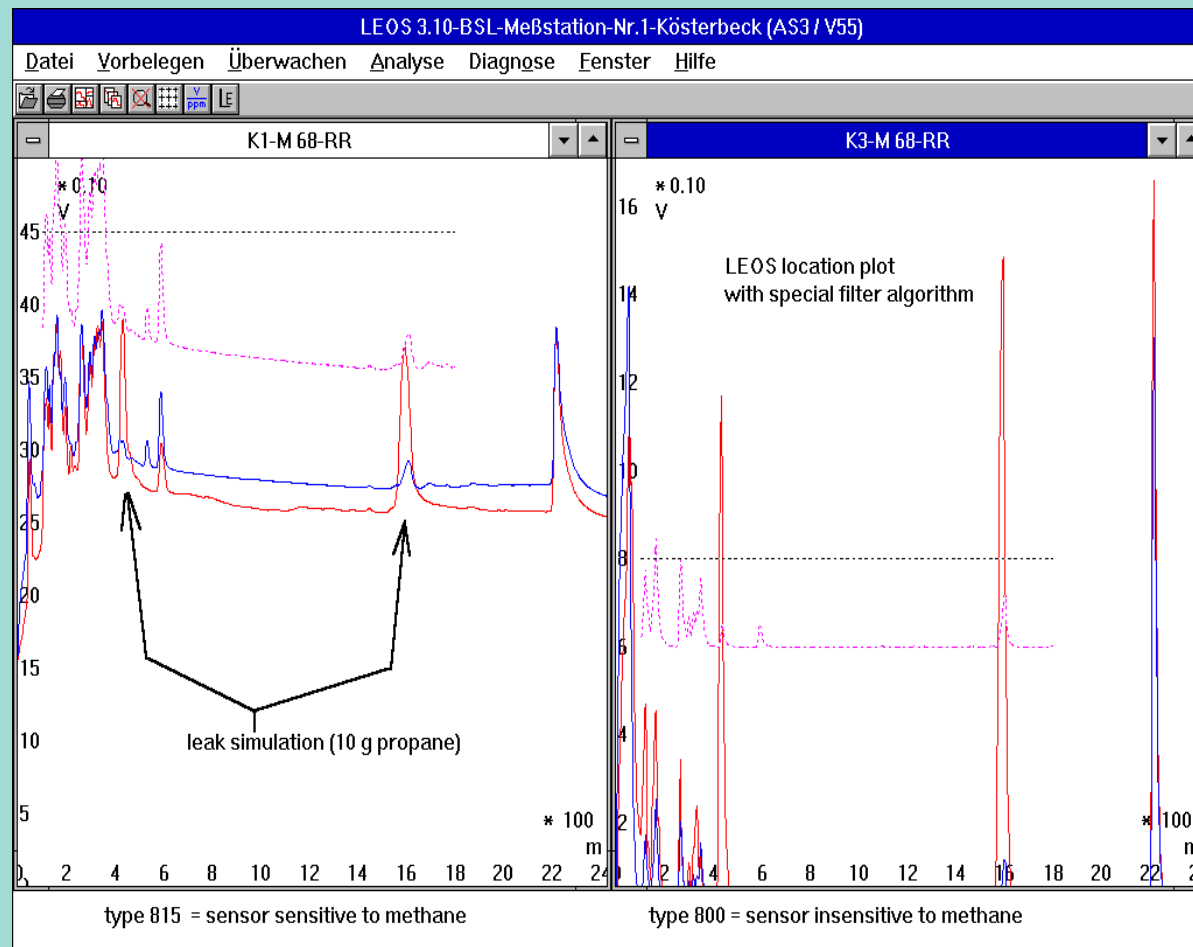

blue = reference measurement, black and dotted = absolute threshold, pink and dotted = relative threshold

LEOS (Leak- and Location System)   **NW-D / 1999**

LEOS 2.11-VEBA-Meßstation-Nr.1-Brösweg

M 638 - R R - Str.Nr. 2

SIEMENS

LEOS Location Plot
Influence of Sensor Type and Filter Algorithm

LEOS 3.10-BSL-Meßstation-Nr.1-Kösterbeck (AS3 / V55)

Datei Vorbelegen Überwachen Analyse Diagnose Fenster Hilfe

K1-M 68-RR

K3-M 68-RR

LEOS location plot
with special filter algorithm

leak simulation (10 g propane)

type 815 = sensor sensitive to methane

type 800 = sensor insensitive to methane

LEOS (Leak- and Location System)   **NW-D / 1999**

SIEMENS

Pipeline monitoring with central computer

Station 2

Station 1

Central computer

LEOS measuring station

Central pipeline monitoring

Pump

Flow

Detector

A / D

*

Temperature

PC

Pressure

DSE 1

*

Air outlet

Station 2

Station 1

⊗ Fault

⊗ Leak alarm

Alarm signalling unit

PC

TPG - control

Leak alarm

Fault

2/1

1/1

Drying cell

Filter cell

Air inlet

Solenoid valve

E cell

Test peak generator

Flow control

⚡ External time synchronization DCF77 signal

——— Option
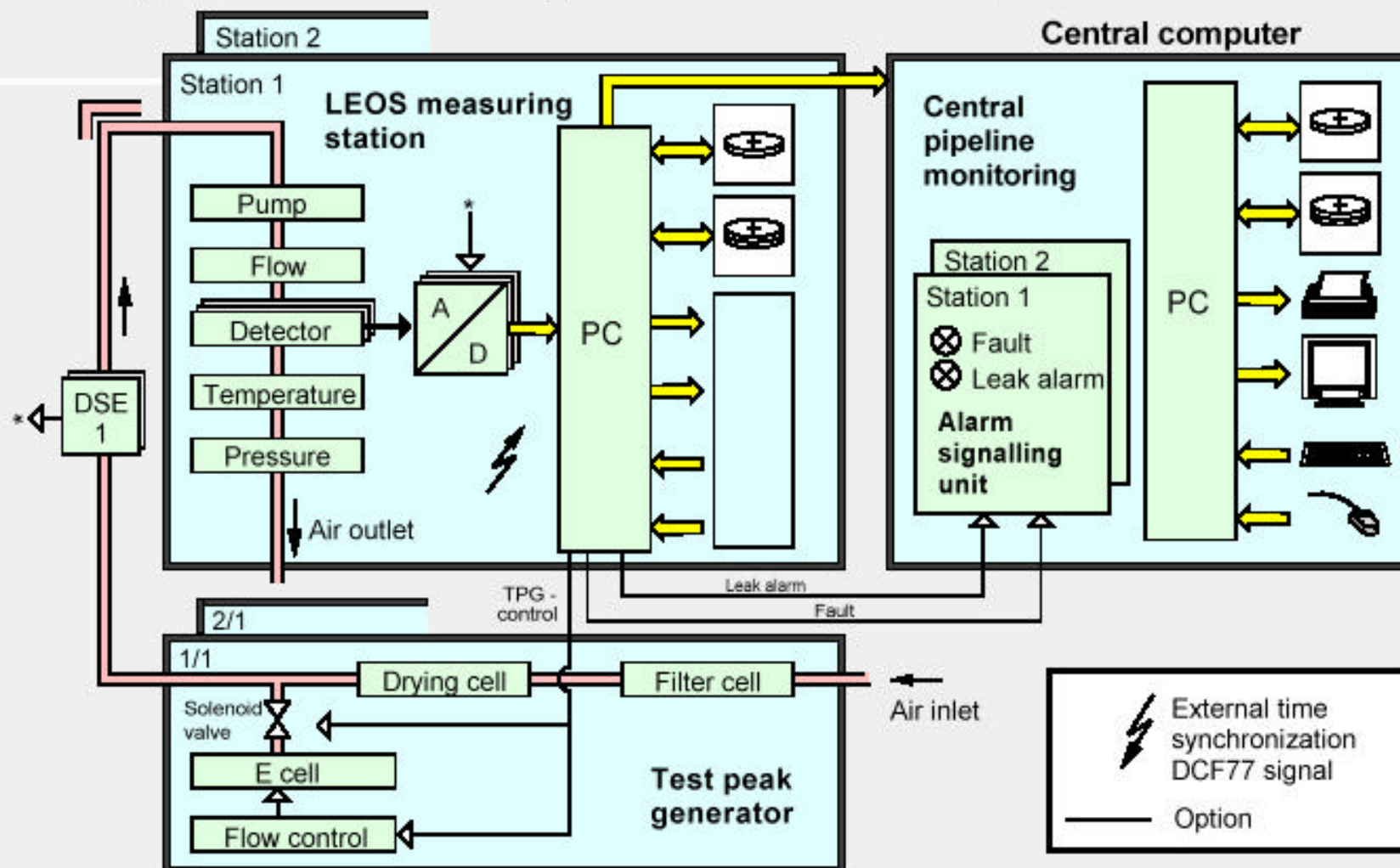
LEOS (leak detection and location system)

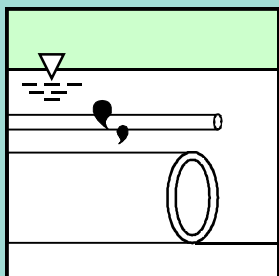**SIEMENS**
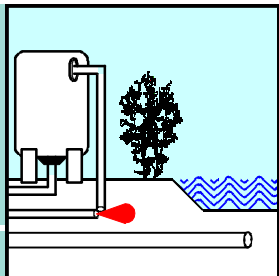
Groundwater Protection Area 1978 BASF AG, Ludwigshafen

Medium transported: *Ethylene $C_2 H_4$* **Piping length:** *4km*

Configuration: *above groundwater level, sensor tube lies beside pipe*
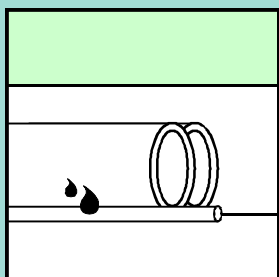
Rhine River Crossing /Foreshore 1978 BASF AG, Ludwigshafen

Medium transported: *Ethylene $C_2 H_4$* **Piping length:** *2 x 1,5 km*

Configuration: *sensor tube at 12 o' clock in Rhine River bed, in a depth of 24 m from the maximum water level*
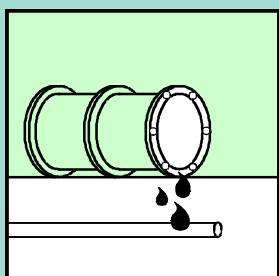
Piping Bundle in Rhine Foreshore 1983 Wintershall AG, Mannheim

Medium transported: *Pentane and nonane cut,* **Piping length:** *2 x 1,5 km*

benzene, aviation fuel,

Configuration: *sensor tube at 12 o' clock in Rhine River bed, in a depth of 24 m from the maximum water level*

Chemical Storage Facility 1987 Cable Factory, Coburg

Medium stored: *Ketone, mixed solvents, oil etc* **monitored area:** *225 m^3*

**Configuration:** *sensor tube laid in ducts below building*

LEOS (Leak- and Location System) NW-D / 1999

SIEMENS

Track Report on Monitoring Function / Field Experience

- LEOS monitoring systems *since 1978 in operation*

- *Small leaks* (valves) localized on pipelines during operation

- *No leak undetected* including field tests

- *Qualified system for water protection* in Germany

- *Natural Methane emissions* by organic processes

- Other background emissions from *industrial pollutions*

LEOS (Leak- and Location System)   **NW-D / 1999**

SIEMENS
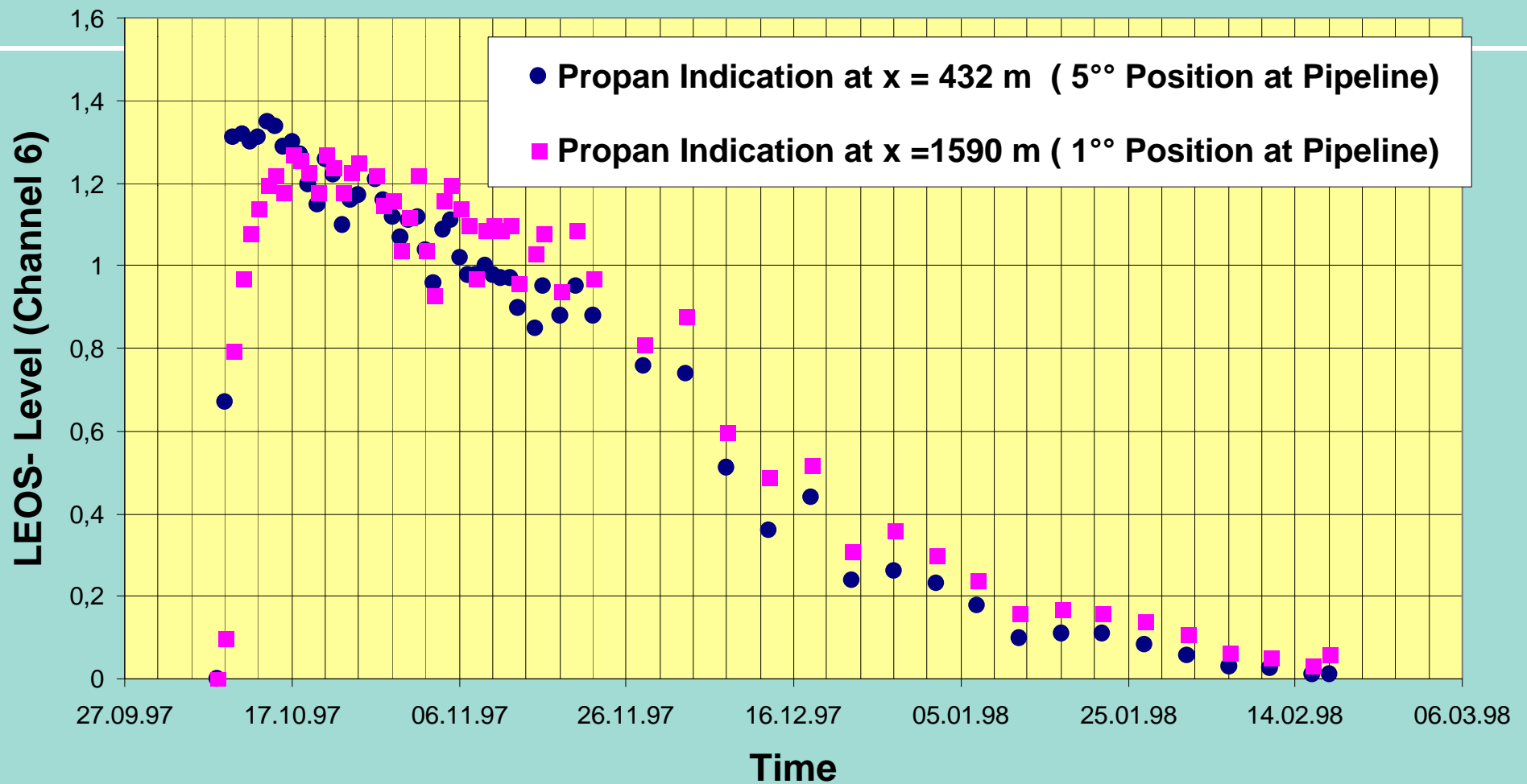
Experience on System Function

- **100 % reliability** of installed sensor tube buried in soil or water

- High reliable **electronic components**

- **Automatic** monitoring with specified capabilities

- Low effort of **maintenance**

- **Module technique** allows simple adaption to monitoring task (loop or split systems, up to 8 monitoring lines for each system)

LEOS (Leak- and Location System)   **NW-D / 1999**

SIEMENS

BPXA Northstar Project

Stipulation of Army Corps of Engineers:

"oil spill leak detection system"

Design Basis: 15 years , plus

6 miles subsea oil pipeline

water depth 0 to 39 ft, burial depth 5 to 11 ft

60 °F operating temperature

ambient air temperature during construction : - 50°F
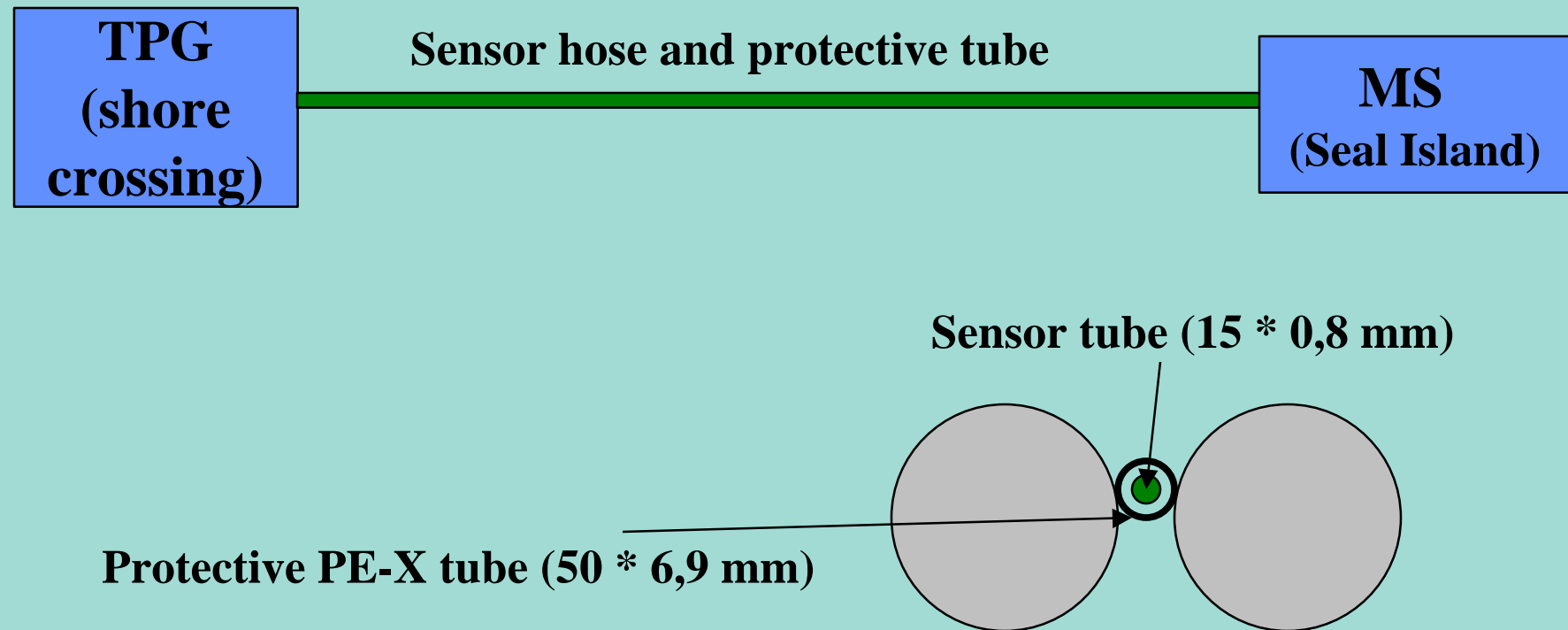
high salinity

Sensitivity: < 1 bbl/day (32.5 bbl/day requested)

Performance requirements:

no false alarms

robust to survive installation and long-term operation

LEOS (Leak- and Location System)   NW-D / 1999

SIEMENS

Main LEOS Components of Northstar Project

TPG (shore crossing)

Sensor hose and protective tube

MS (Seal Island)

Sensor tube (15 * 0,8 mm)

Protective PE-X tube (50 * 6,9 mm)

LEOS (Leak- and Location System)

NW-D / 1999

SIEMENS

Construction Considerations - Protection during Installation

Accidental mechanical impact, abrasion due to handling etc.
• Sensor hose will be laid in a protective perforated tube made by PE-X
   designed for high dynamic and static loads
• Sensor hose and PE-X assembly will be delivered on 300 m coils
   and unreeled on ice to straight length
• splice and repair technique in the field

Low ambient temperature
• modified inner sensor tube made from PVDF
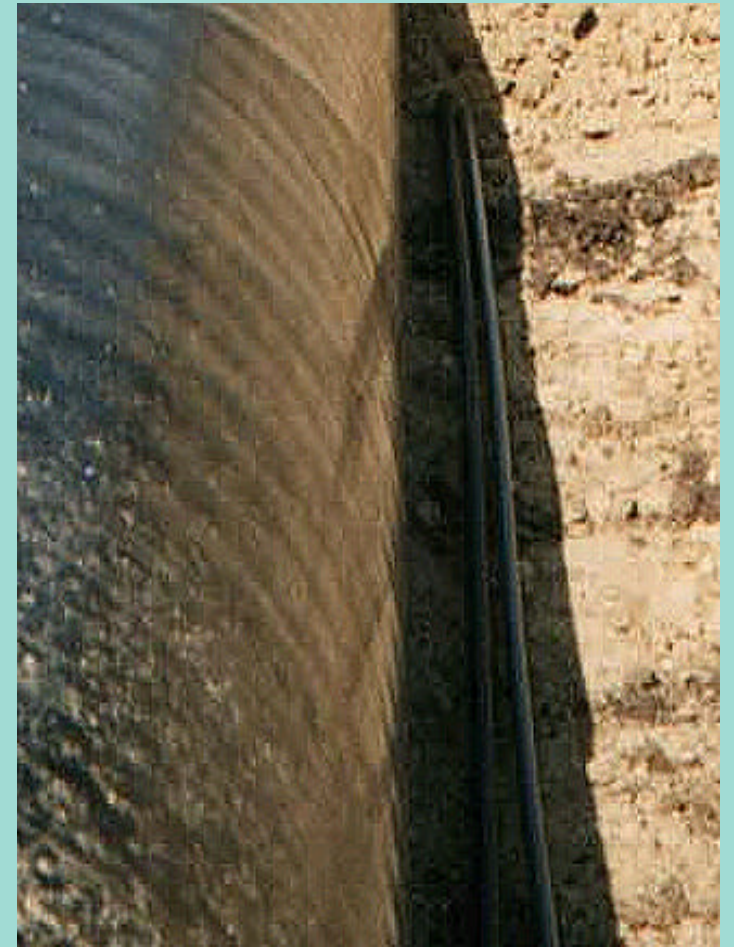
Quality Management during Installation
• Pressure tests of the sensor hose after each relevant step
• Final pressure test of the complete monitoring line

LEOS (Leak- and Location System)   NW-D / 1999

SIEMENS

Crude Oil Pipeline in Water Protected Areas

LEOS (Leak- and Location System)   NW-D / 1999
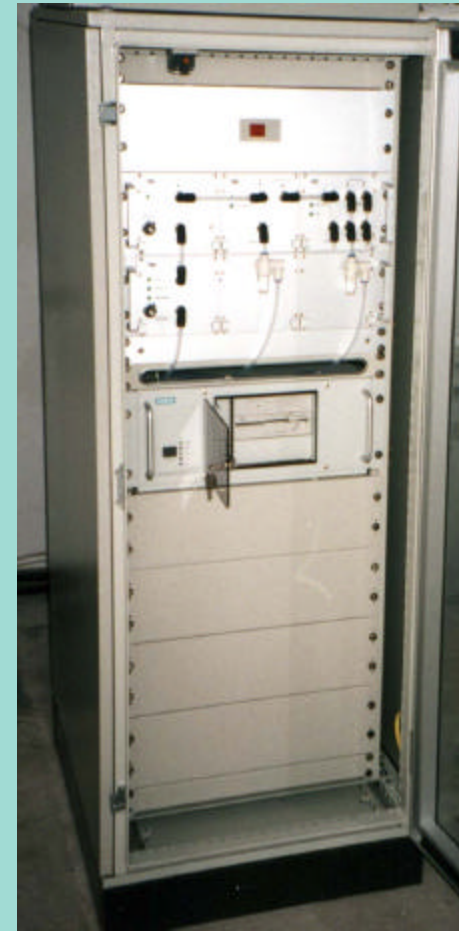
SIEMENS

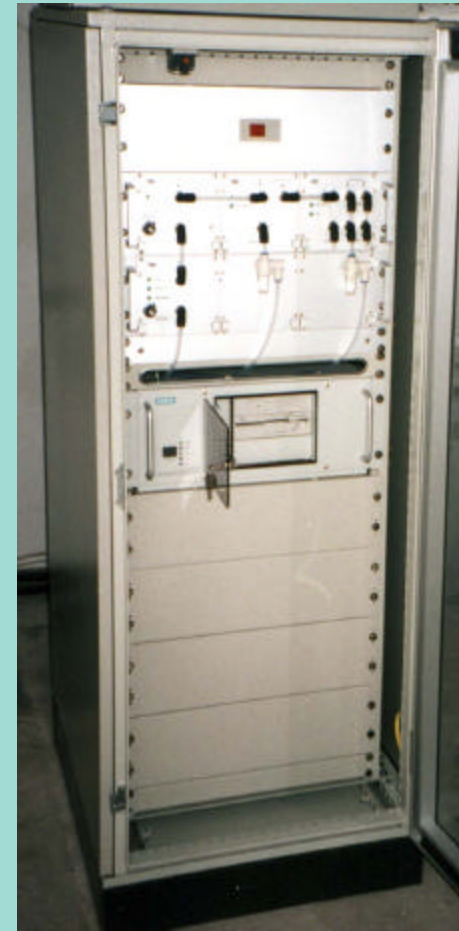# Measuring System Cabinet

LEOS (Leak- and Location System)

NW-D / 1999

SIEMENS

Measuring System Cabinet

LEOS (Leak- and Location System)

NW-D / 1999

SIEMENS

Crude Oil Pipeline in Water Protected Areas

LEOS (<u>L</u>eak- and <u>Lo</u>cation <u>S</u>ystem)   NW-D / 1999

SIEMENS

Field Tests of Leak Detection Sensitivity

LEOS (Leak- and Location System)

NW-D / 1999

SIEMENS

LEOS Sensor Tubes

LEOS (Leak- and Location System)   **NW-D / 1999**